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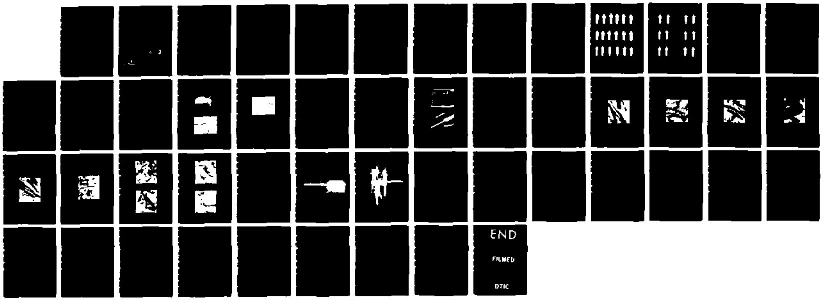

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HEXANITROSTILBENE: REVIEW OF SHIELDED MILD DETONATING CORD PERFORMANCE - III

BY E. EUGENE KILMER

RESEARCH AND TECHNOLOGY DEPARTMENT

31 AUGUST 1984

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The results of a study to determine the performance of selected shielded mild detonating cords (SMDC), subjected to elevated temperatures of 218°C (425°F), 260°C (500°F), and 282°C (540°F) are presented herein. The purpose of the work was to determine the response of hexanitrostilbene produced in the United States and England with respect to particle geometry and purity when used in the SMDC design.

20. (Cont.)

All of the HNS samples were acceptable within the specified performance tolerance range in the SMDC, except one sample which assayed high in acid content before being subjected to elevated temperatures.

FOREWORD

This work is a continuation of the study reported in NSWC/WOL TR 79-497, Hexanitrostilbene (HNS): Review of Industrial Syntheses and Recrystallizations-I and NSWC/WOL TR 80-13, Hexanitrostilbene (HNS): Review of Chemical Assays and Detonating Cord Performance-II. This work is currently sponsored by the Lyndon B. Johnson Manned Spacecraft Center, Task NASA R12ZB and the Strategic Systems Project Office, Task B00035B001, R12KU.

The author wishes to acknowledge the QUEST work of Mr. M. L. Schimmel of McDonnell Douglas Corp., the results of the chemical assays by Ms. Eleanore Kayser, the detonation velocity study by Mr. Charles Goode, and the scanning electron photomicroscopy by Dr. Marriner Norr of the Naval Surface Weapons Center.

The identification of vendors or commercial products implies no criticism or endorsement by the Naval Surface Weapons Center.

Approved by:

J. F. PROCTOR, Head
Energetic Materials Division

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INTRODUCTION

The purpose of this work was to determine the effect, if any, that the impurities within the Hexanitrostilbene (HNS) exhibit on the performance of shielded mild detonating cords (SMDC) when exposed to elevated temperatures.

The results of earlier work[1] have shown that HNS loaded into detonating cords will perform at an elevated temperature of 218°C (425°F), but that the reliability to sustain detonation over a period of time is dependent on the final loading density of the cord. Work done by Gould[2] of Sandia Laboratories suggests that different chemical mechanisms for thermal decomposition of HNS will exist when the explosive is recrystallized from acetonitrile-toluene and when the explosive is recrystallized from nitric acid solvent. Recent work[3] shows definite problem areas associated with detonating cords fabricated from HNS explosive which was recrystallized from nitric acid.

It was assumed for this study that the major impurity affecting the thermal stability and performance of hexanitrostilbene was hexanitrobibenzyl (HNBiB). An experiment was then designed to include various percentages of HNBiB in the explosive mixture that was to be loaded into detonating cord hardware.

The test hardware used in the experiment was SMDC end tips, loaded with HNS-I which was produced from various vendors. These end tips were fabricated by Explosive Technology with GFE (HNS) from NSWC. The experiment was designed to test hardware at three different elevated temperatures.

The variability in the particle size and geometry of the HNS-I being produced raised the question of possible variable sensitivity to explosive shock and fragment initiation in explosive ordnance. A study was made of the HNS produced in the United States and Great Britain using SMDC as the test vehicle. The results of these tests indicate that the variable morphology of the HNS did not significantly affect the sensitivity of the material to fragment impact, as determined under the test conditions in the study.

EXPLOSIVE HARDWARE EXPOSURE TO ELEVATED TEMPERATURES

The first group of SMDC end tips were exposed to a temperature of 218°C (425°F). Samples were removed after 4, 8, and 24 hours of exposure, and are shown in Figure 1. The second group was exposed at 260°C (500°F) for 2 hours, and they are shown in Figure 2.

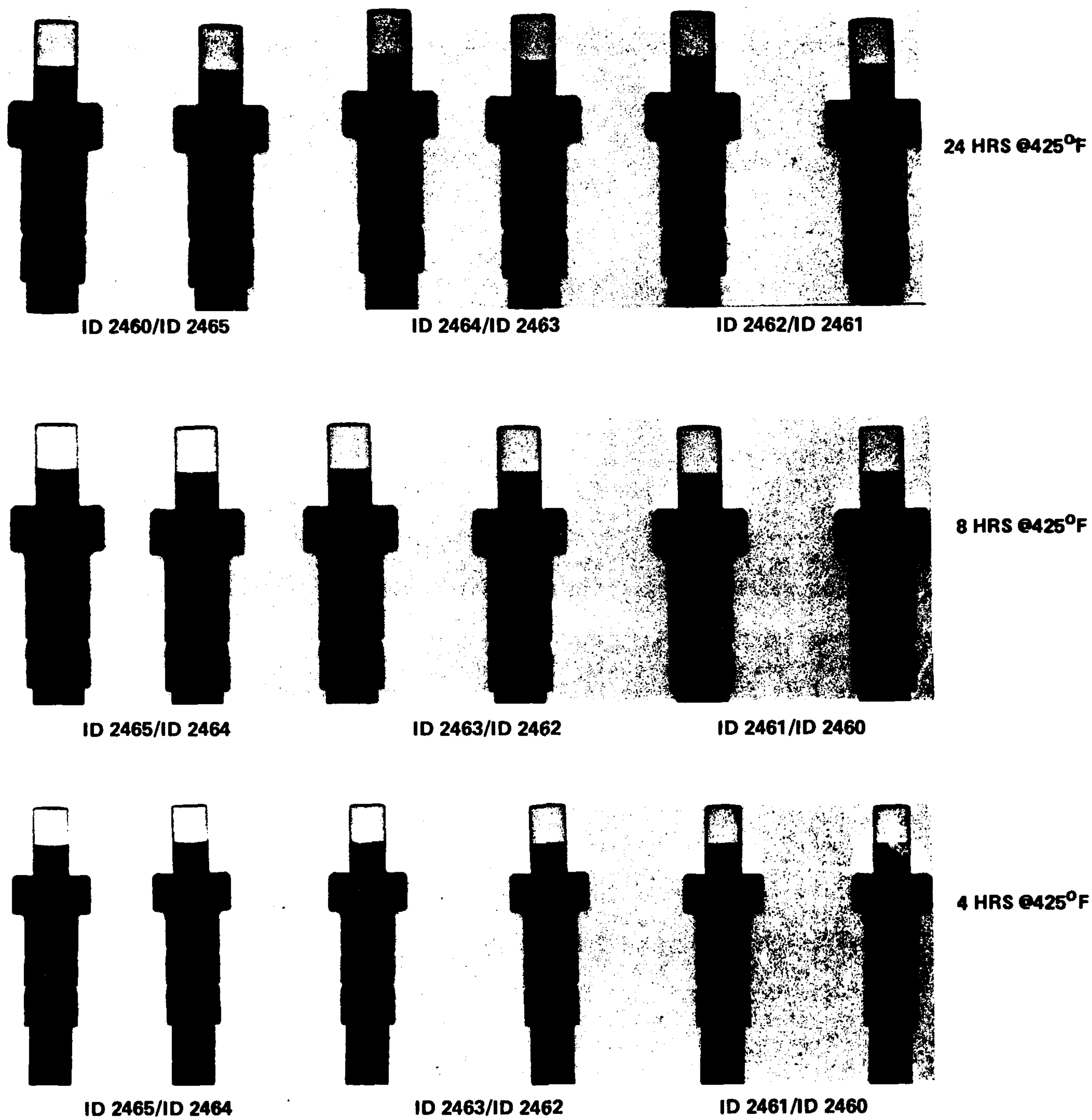


FIGURE 1. X-RAY PRINT OF SMDC TIPS EXPOSED AT 425°F

2 HRS. 500°F

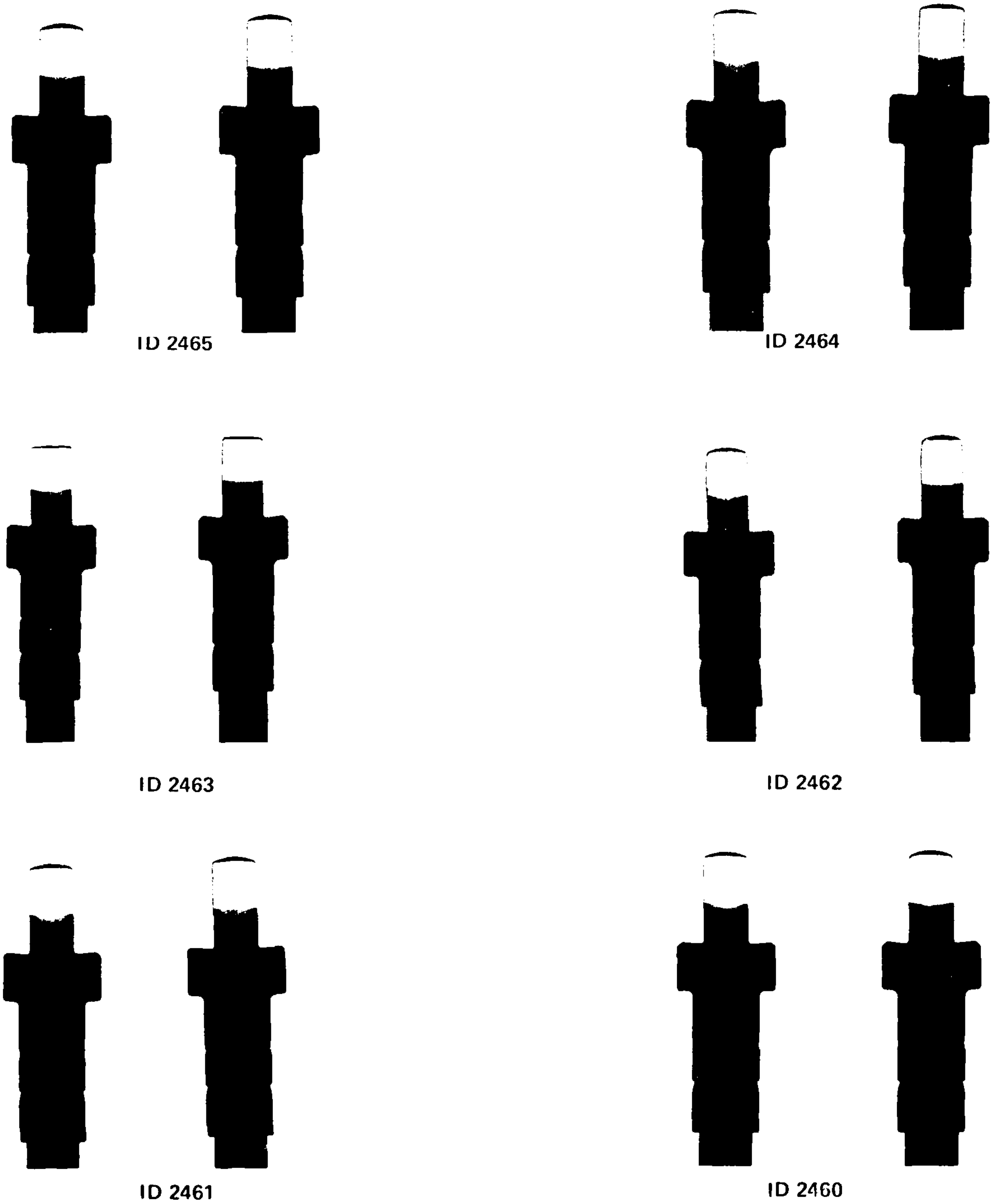


FIGURE 2. X-RAY PRINT OF SMDC TIPS EXPOSED AT 500°F

Chemical analysis using High Performance Liquid Chromotography (HPLC) was run on each group to determine the HNS purity before elevated temperature exposure (Table 1). A tabulation of the HNS chemical assays (from HPLC and nitric acid analyses) is shown in Table 1. It should be noted that the selection of explosives was based upon the percentages of HNBiB in each sample. The quantity of impurity (HNBiB) was preselected to be within the range of 0.4 to 6.7 percent (HPLC assay). These are typical extreme values found in representative samples from industrial production lots.

Performance was determined by (1) the results of detonation velocity measurements and (2) the output dent from an explosive pellet initiated by the SMDC tip. A sketch of the performance test arrangement is shown in Figure 3.

The variables associated with the experiment to determine the performance of HNS-I at elevated temperatures were: (1) the purity of the material and (2) the exposure to temperatures between 425°F and 540°F for 1-1/2 to 24 hours. The exposure time was adjusted depending on the temperature. The chemical data in Table 1 shows impurities such as HNBiB and TNB to be the main constituents in HNS. Photographic copies were made from the X-rays of the tips which had been exposed to 425°F and 500°F. These photographs indicate some gaseous decomposition which resulted in "cup bulging." In one case, the cups fractured. Problems in the reliability of detonation transfer were expected because of the bulging and fracturing of the cups and because of possible problems with the explosive column. The first British sample (ID 2461) has the highest acid content (0.08 percent) and is the only one in which detonation transfer failure occurred. This result is consistent with previous results which have shown that acid has caused detonation failures in cords fabricated with HNS-II, when the HNS-II was recrystallized from nitric acid.[3] By way of comparison, the other British sample ID 2465 (which assayed low in residual acid) managed to perform properly at 500°F. A minimum amount of residual acid allowable could not be specified, but it is probably less than 0.08 percent, as shown in Table 1. HNS produced in the U.S. by methods other than those using an acid wash, performed satisfactorily at this temperature. The detonation velocities are shown in Tables 2 and 3 along with steel dent output results from the booster detonation transfer.

The detonation transfer did not appear to be affected in the samples exposed at 425°F over the short period of time investigated. The performance of the end booster was determined by its ability to initiate an explosive pellet as shown by the schematic in Figure 3. Results with samples exposed at 218°C (425°F), as shown in Table 2, indicate detonation transfer between the end booster and the CH-6 pellet was satisfactory.

Results of tests of the end booster to initiate the CH-6 are also satisfactory after exposure to 500°F except for the sample, ID 2461. This information is tabulated in Table 3. An analysis of the end booster indicates the explosive did not detonate at this point. A photograph of the items which failed to transfer are shown in Figure 4. Burning of the explosive in the end booster typically blackens the CH-6 pellet. An example of an end booster which performed properly is shown in Figure 5A along with the failed unit from the ID 2461 sample (Figure 5B).

TABLE 1. QUANTITATIVE HNS DATA*--SMDC TIPS (CONTROL)

SMDC IDENT.	MFG. LOT # EXPLOSIVE	EXPL. IDENT.	% HNS	% HNBiB	% TNB	HNO_3 ASSAY %
2460	Tel/M/S 1014**	2130/2134	93.0	6.7	0	0.00
2462	UTC #3***	2297	94.5	4.6	0.1	0.00
2464	UTC #8	2413	96.7	3.2	0.1	--
2461	PERME B343†	2232	97.8	1.9	0.3	0.08
2465	PERME B553	2417	98.9	0.9	0.2	0.01
2463	Pantex 7157-07C-001††	2407	99.6	0.4	0	--

*All values are from HNS-I removed from SMDC cup after loading and prior to elevated temperature exposure.

**Teledyne McCormick Selph
ted Technologies Corp.
Waltham Abbey, Essex, England
††Mason & Hanger-Silas Mason Co. (Pantex Plant)

FIGURE 11. HEXANITROSTILBENE: CHEMTRONICS 64-19 (ID 2087)

FIGURE 10. HEXANITROSTILBENE: UNITED TECH. INC. 3 (ID 2297)

FIGURE 9. HEXANITROSTILBENE: NSWC 96-8433-48–2 (ID 2247)

FIGURE 8. HEXANITROSTILBENE: BRITISH PERME 343 (ID 2232)

TABLE 5. HNS IDENTIFICATION

NSWC IDENT. NO.	VENDOR	LOT NO.	HNS TYPE
2232	British	PERME 343	I
2247	NSWC	96-8433-48#2	I
2297	United Tech. Inc.	3	I
2087	Chemtronics	64-19	I
2130/2134	Tel/McC/S	1125	I
1479	Del Mar Engineering	250-7	II
2299	Silas Mason Hanger	6348-07H-001	II
2323	Ensign Bickford	30	II

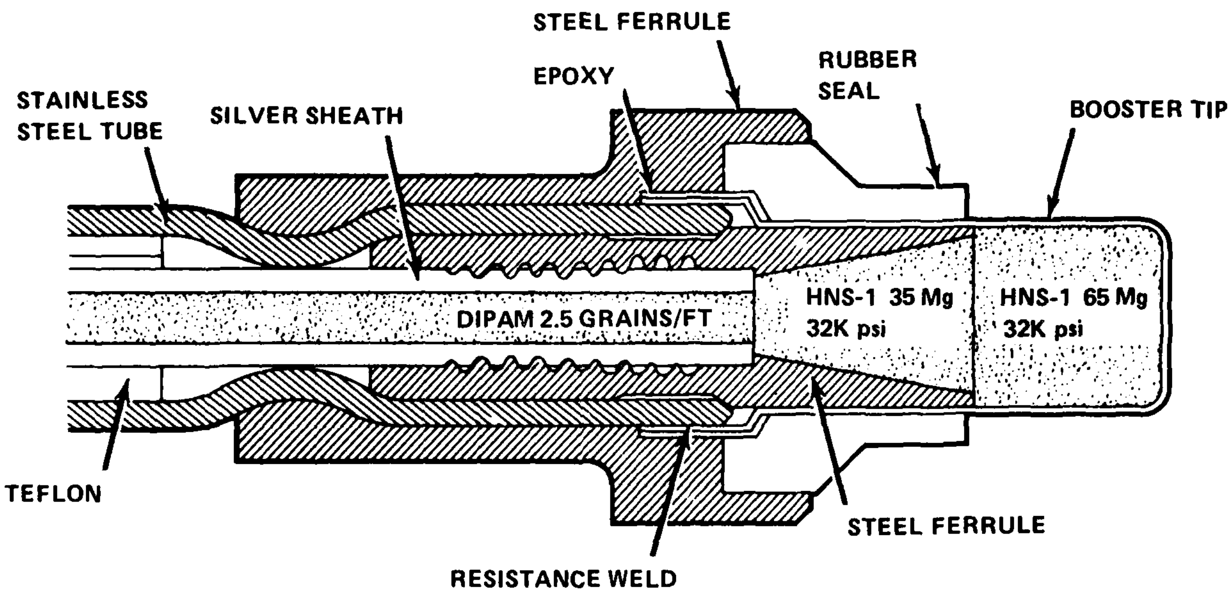


FIGURE 7. SMDC END TIP HARDWARE (McDONNELL DOUGLAS CORP.)

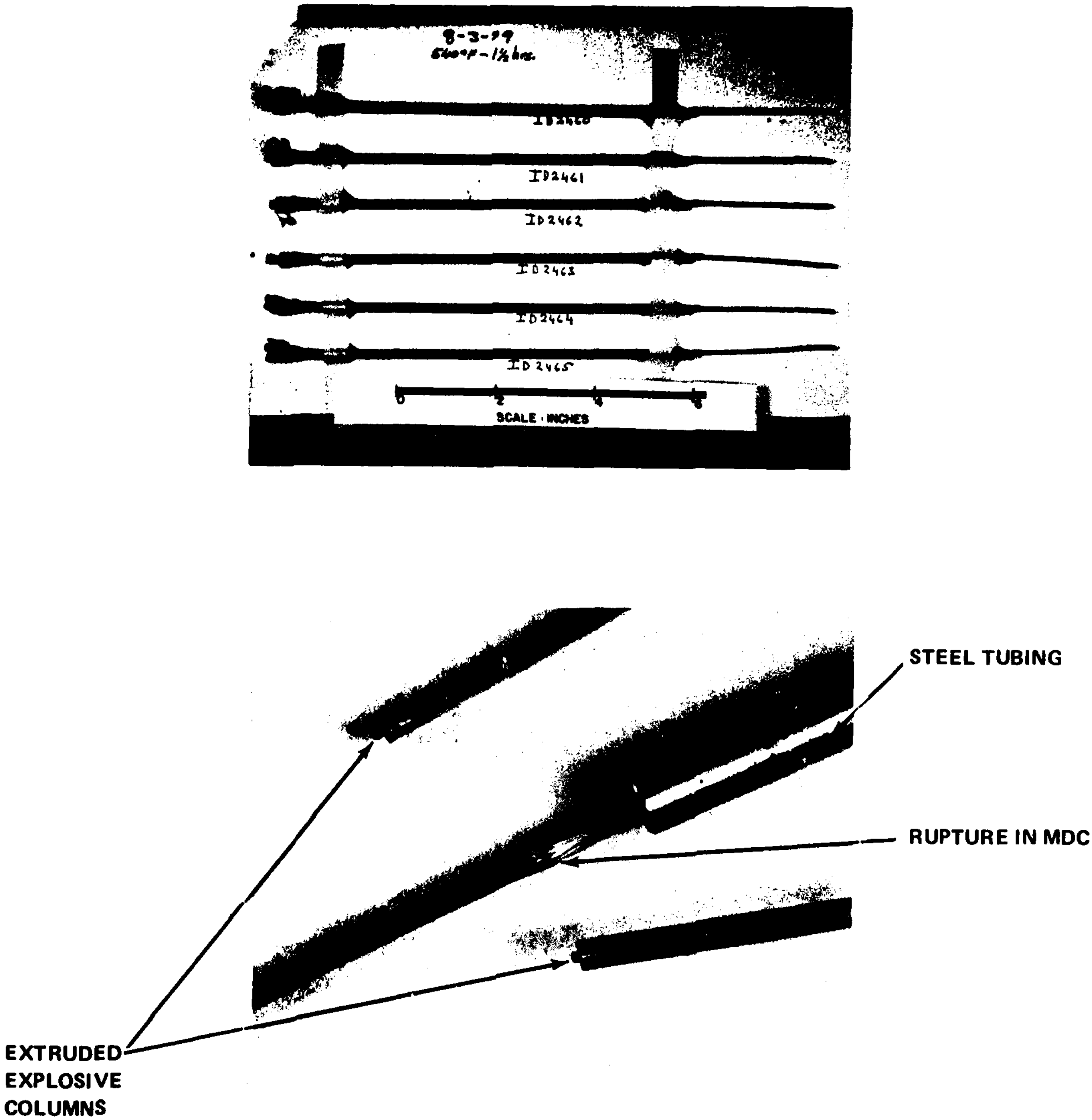


FIGURE 6. SMDC END BOOSTERS WHICH DEFLAGRATED DURING 280°C (540°F) TEMPERATURE EXPOSURE

TABLE 4. EXPLOSIVE PERFORMANCE OF SMDC TIPS EXPOSED TO 280°C (540°F)

SMDC ASSEMBLY NSWC IDENT.	END TIP EXPLOSIVE MFG./LOT #	END TIP NSWC EXPL. IDENT.	HOURS OF EXPOSURE	
2460	Tel/M/S 1014	2130/2134	1-1/2	
2462	UTC #3	2297	1-1/2	
2464	UTC #8	2413	1-1/2	All SMDC tips deflagrated during the exposure time.
2461	PERME B343	2232	1-1/2	
2465	PERME B555	2417	1-1/2	
2463	Pantex 7157-07C-001	2407	1-1/2	

The highest temperature that the SMDC tips were exposed to in this program was 280°C (540°F). The results from this test were as expected. The HNS in the booster tips deflagrated during the 1-1/2 hours exposure time and ruptured the cups. The SMDC tip identifications are again tabulated in Table 4. The performance of HNS-I was also not considered to be satisfactory after exposure to 540°F. The HNS-II loaded into the detonating cords also showed thermal degradation. Observations of the results from the X-ray film show blisters or irregularities in the mild detonating cord (MDC). The photograph of the hardware, as shown in Figure 6, is indicative of the results of the decomposition and deflagration of the explosive. A phase change in the explosive or a gas "build-up" caused the column to extrude from the MDC sheath. A temperature of 540°F is too high as an upper limit, and should probably be reduced below 500°F. In view of the overall results of the reduced velocities in the SMDC lines, 500°F is also too high a temperature to expect a reliable performance in the hardware.

SMDC SENSITIVITY TO FRAGMENT INITIATION

The objective of this work was to determine if the variability in the particle size and geometry of the HNS-I, currently produced by industry, would affect its response to fragment initiation stimuli. The test vehicle chosen for this study was the standard SMDC end booster. A cutaway view of this piece of ordnance is shown in Figure 7.

A number of bulk HNS samples obtained from various manufacturers were sent to the McDonnell Douglas Corporation at St. Louis, Missouri, for testing by the QUEST method.[4,5] The first group of explosives loaded and tested are listed in Table 5. The explosives selected were typical samples from production lots that each vendor produces according to his own proprietary techniques. Scanning electron photomicrographs (SEM) taken of each sample are shown in Figures 8 through 15 to document the morphology of the crystalline explosive.

The test technique used to determine the sensitivity of the explosives to fragment impact was originally developed as part of the study in Reference 4. Sketches of the test hardware with details of design configurations are shown in Figure 16. The data collected in this study were obtained using two test configurations for the SMDC end boosters: end-to-end and side-to-end. The hardware used in the end-to-end (donor-to-acceptor) test configuration is shown in Figure 17. With a constant 1/2-inch air-gap, the tests variable was the thickness of the steel shim placed between the donor and acceptor end booster. A top view of the side-to-end configuration is shown in Figure 18. A constant 1/10-inch air-gap test increment was used for this test configuration. Side-to-end initiation is always more difficult than end-to-end initiation and therefore requires a reduced air-gap to accomplish detonation transfer.

It should be pointed out that the test results in Reference 4 show that HNS-I is more sensitive to fragment initiation than HNS-II. In addition, the samples tested in that study show that at the 50 percent response level of the acceptor-closure thickness of shim, the shim was approximately twice as thick for the HNS-I (NSWC ID 537) as for the HNS-II (NSWC ID 528).

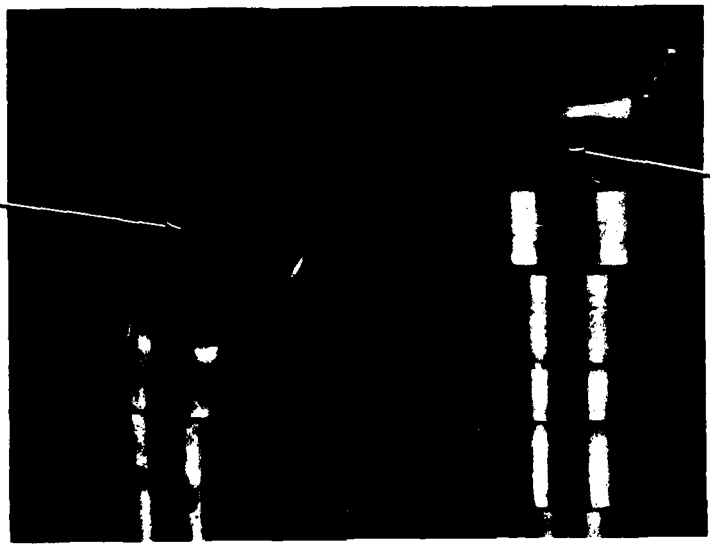


FIGURE 5. COMPARISON OF SMDC TIPS FROM DETONATION TRANSFER TESTS

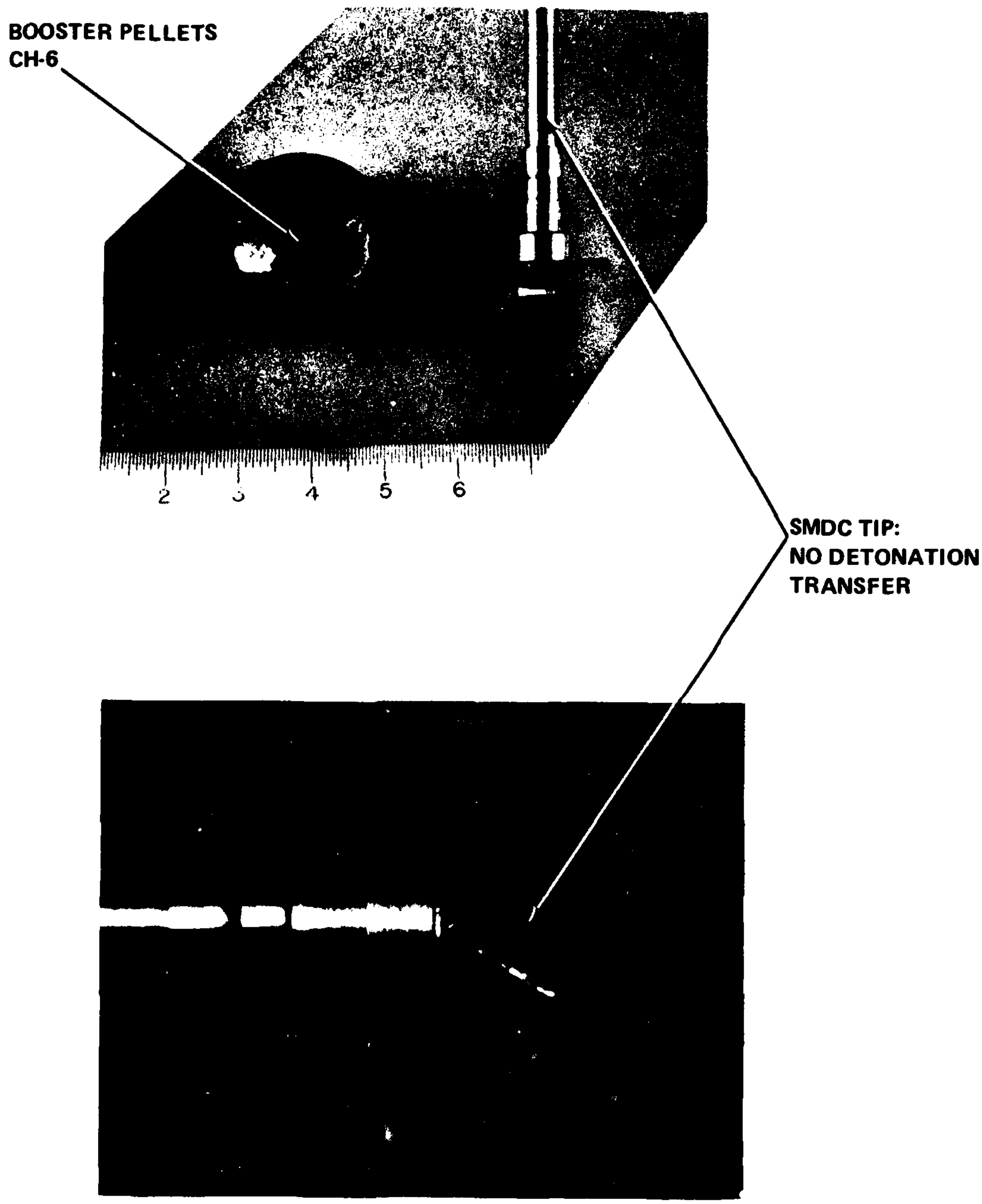


FIGURE 4. RESULTS OF DETONATION TRANSFER TEST–SMDC: EXPLOSIVE BOOSTER PELLET

TABLE 3. EXPLOSIVE PERFORMANCE OF SMDC TIPS AGED AT 260°C (500°F)

SMDC ASSEMBLY NSWC IDENT.	END TIP EXPLOSIVE MFG./LOT #	END TIP NSWC EXPL. IDENT	HOURS OF EXPOSURE	SMDC ASSEMBLY DETONATION-VELOCITY (m/s)*	STEEL DENT (mils)
2460**	Tel/M/S 1014	2130/2134	2	6235	95
2462**	UTC #3	2297	2	6196	100
2464**	UTC #8	2413	2	6175	95
2461†	PERME B343	2232	2	5523	End Tip Transfer Failure
2465**	PERME B555	2417	2	6386	99
2463	Pantex 7157-07C-001	2407	2	6175	95

*Control sample of SMDC has a value of 6773 m/s with no exposure to temperature. (Same as Table 2.)

**Visual and X-ray film observation of the end tip (cup) showed bulging at the bottom of the cup and radially along the diameter of the cup prior to functioning.

†Visual and X-ray film showed a fracture in the wall of the cup located over the explosive charge and extending along the long axis of the cup for a distance of about 0.2" prior to functioning.

TABLE 2. EXPLOSIVE PERFORMANCE OF SMDC TIPS AGED AT 218°C (425°F)

SMDC ASSEMBLY NSWC IDENT.	END TIP EXPLOSIVE MFG./LOT #	END TIP NSWC EXPL. IDENT.	HOURS OF EXPOSURE	SMDC ASSEMBLY DETONATION-VELOCITY (m/s)*	STEEL DENT (mils)
2460	Tel/M/S 1014	2130/2134	4	6719	91
			8	6735	91
			24	6644	100
2462	UTC #3	2297	4	6760	101
			8	6694	95
			24	6652	90
2464	UTC #8	2413	4	6756	94
			8	6764	88
			24	6700	94
2461	PERME B343	2232	4	6680	99
			8	6559	97
			24	6474	97
2465	PERME B553	2417	4	6711	92
			8	6754	92
			24	6680	99
2463	Pantex 7157-07C-001	2407	4	6741	89
			8	6746	97
			24	6709	94

*NOTE: MDC in SMDC Lines--All SMDC lines contain MDC from the same lot but different explosive end tips. Detonation velocity of MDC removed from ID 2464 was 6773 m/sec at room temperature with no exposure to elevated temperature. Explosive in MDC was ET Lot S60-7 (Del Mar Engr. Lot #272-25). This cord was common to all SMDC's tested.

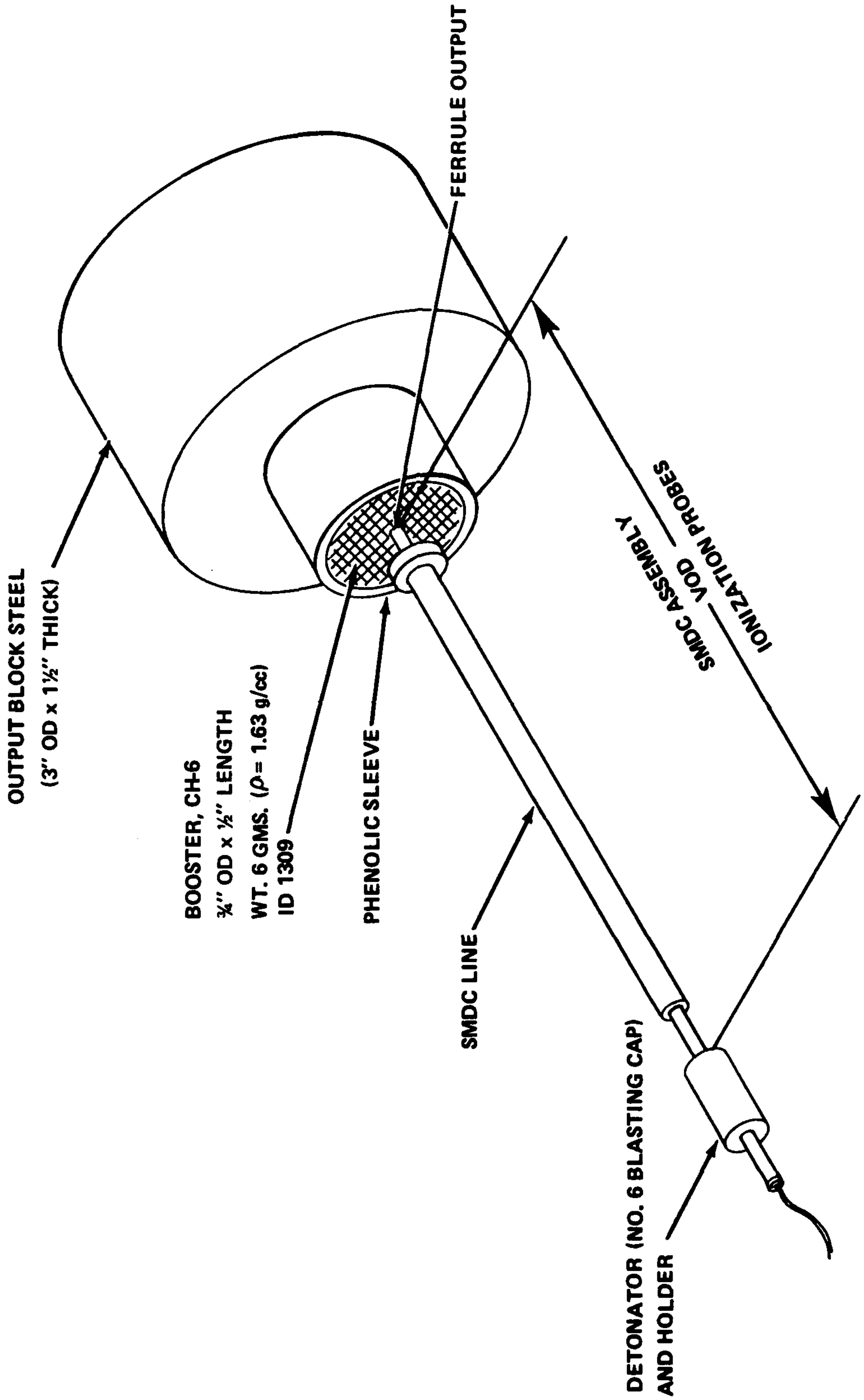


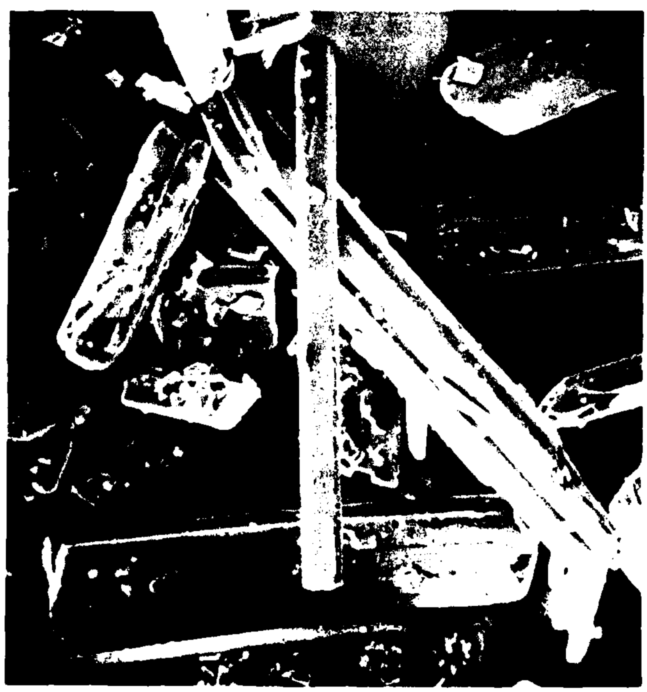
FIGURE 3. HARDWARE TEST ARRANGEMENT

FIGURE 12. HEXANITROSTILBENE: TEL/McC/S 1125 (ID 2134)

FIGURE 13. HEXANITROSTILBENE: DEL MAR ENG. 250-7 (ID 1479)

100 X ID 2299 1 cm = 100μ

0 1 2



250 X ID 2299 1 cm = 40μ

0 1 2

FIGURE 14. HEXANITROSTILBENE: SILAS MASON HANGER 6348-07H-001 (ID 2299)

100 X | ID 2323 | 1 cm = 100μ

0 1 2

250 X | ID 2323 | 1 cm = 40μ

0 1 2

FIGURE 15. HEXANITROSTILBENE: ENSIGN BICKFORD 30 (ID 2323)

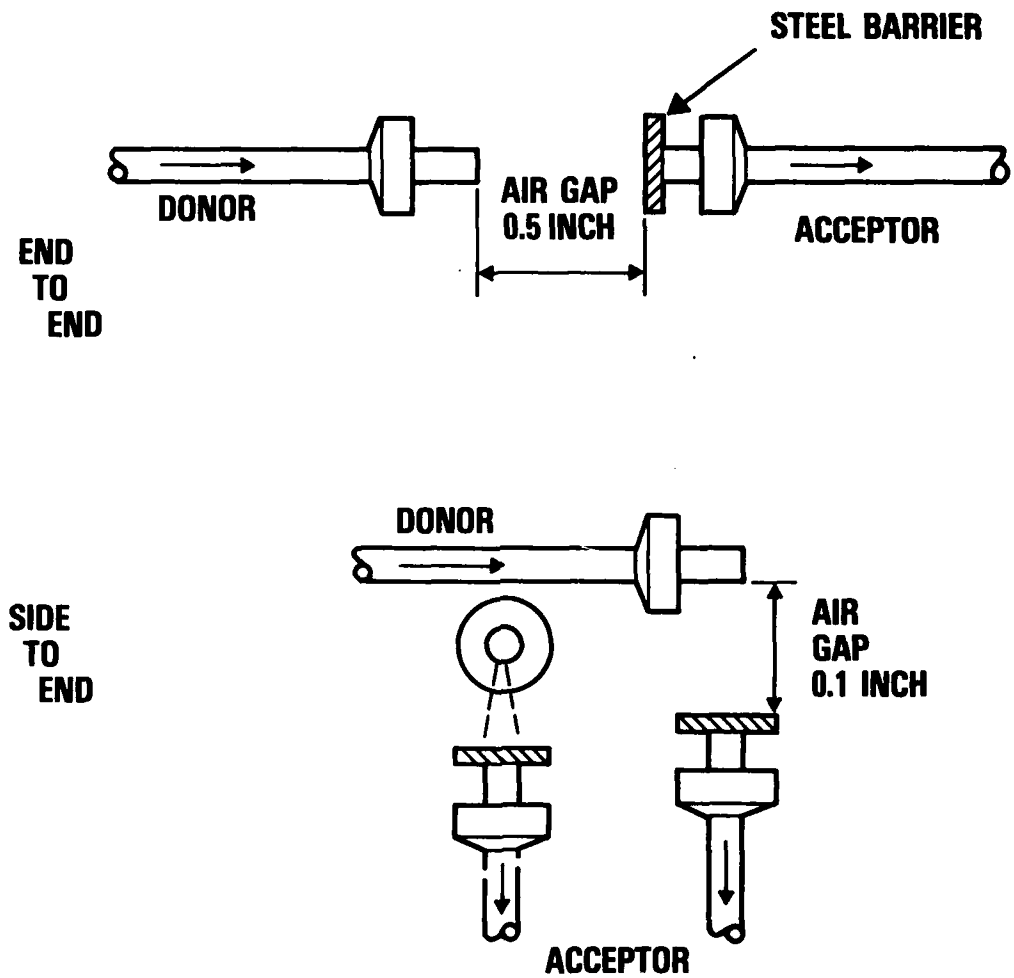


FIGURE 16. DETONATION TRANSFER ARRANGEMENT (MCDONNELL DOUGLAS CORP.)

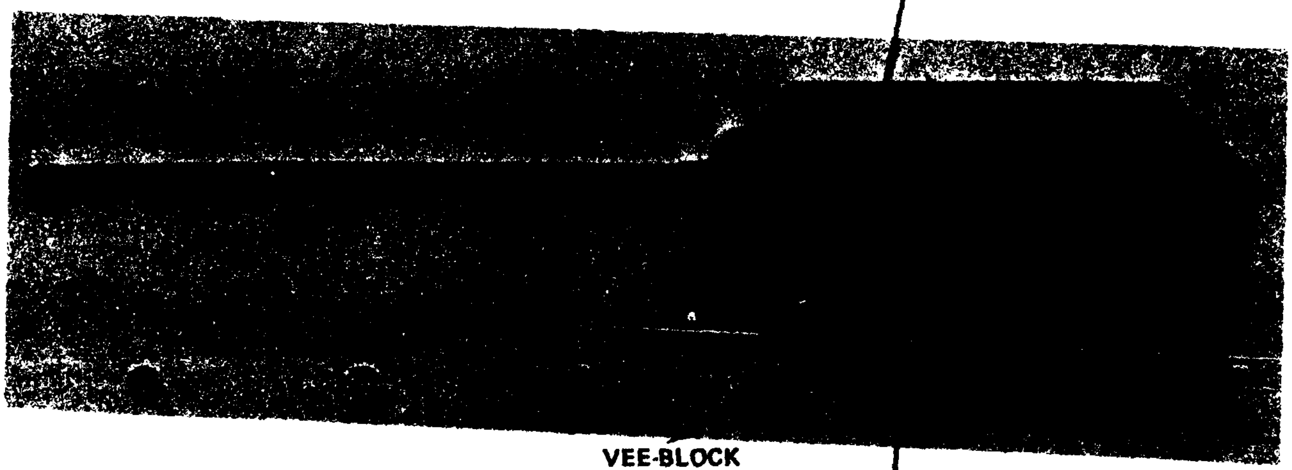


FIGURE 17. END-TO-END TEST ARRANGEMENT (MCDONNELL DOUGLAS CORP.)

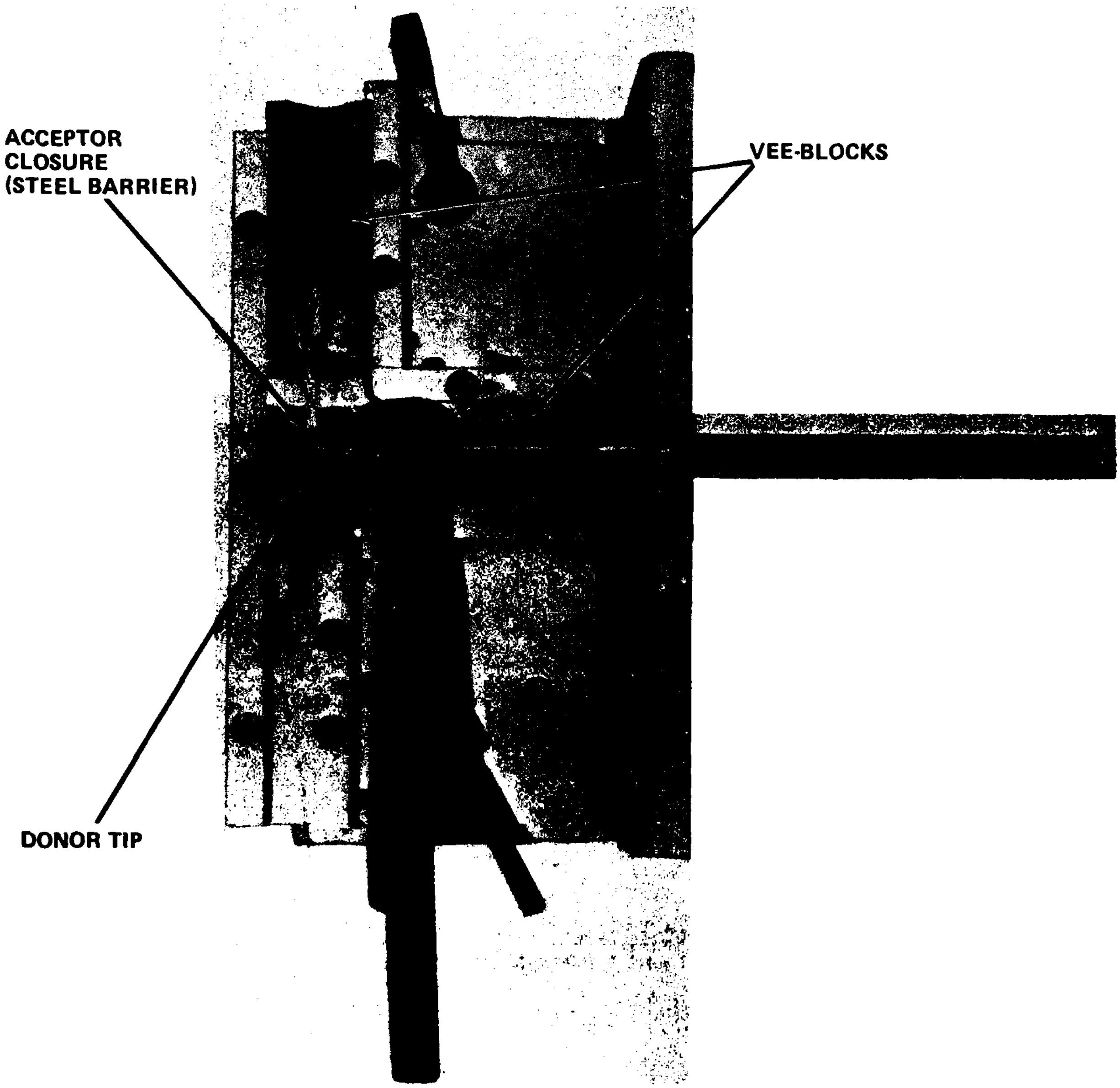


FIGURE 18. SIDE-TO-END TEST SETUP (MCDONNELL DOUGLAS CORP.)

The data collected by McDonnell Douglas Corporation using the QUEST method is summarized in Table 6. End-to-end configuration testing shows the approximate 50 percent response level of HNS-II in this configuration. These test results not only confirm the sensitivity difference between HNS-I and HNS-II, as measured in Reference 4, but also show that the test will distinguish between the sensitivity of HNS-I samples. This test, however, is not sensitive enough to differentiate sensitivity between samples of comparable particle size. As is shown in Figure 11, ID 2087, this HNS-I was larger in particle size than the HNS-I explosives in Figures 8, 9, 10, and 12. HNS sample ID 2087 was found to be less sensitive to fragment initiation than the other smaller sized HNS-I particles as is shown in Table 6. However, this conclusion was drawn from a small sample population and should be expanded statistically for a more definitive answer.

If one considers the purity of the explosive, i.e., the percentage of hexanitrobibenzyl and other materials in the HNS, then a review of the chemical assays and fragment sensitivity will indicate that the reaction or sensitivity to fragments is not a function of purity (Table 6). A comparison of the surface areas of the HNS shows the more sensitive HNS-I to have a much greater surface area than the HNS-II. The only sample of HNS-I that deviates in sensitivity from the other samples is HNS-I (ID 2087) which has about half the surface area of most of the HNS-I batches (ID 2297, 2232), which is about 50,000 cm^2/cm^3. These results suggest that there is no significant improvement to fragment initiation when the surface area exceeds 27,000 cm^2/cm^3. This can be seen in a plot of the steel barrier thickness versus the surface area in Figure 19. In addition, a comparison of barrier thicknesses reveals that HNS-II is too insensitive to be used in the end cup of the SMDC end booster. The data in Figure 20 indicate HNS-II will not initiate in a side-to-end configuration when the steel booster cup thickness is greater than 3 mils (50 percent fire response). The implication here is that, since the stainless steel cup used to enclose the end booster on a standard SMDC tip measures 5 mils thick, it would cause reliability problems in the side-to-end configuration.

ACCEPTABILITY OF HNS-I IN HARDWARE PERFORMANCE

The acceptability of various lots of HNS-I, produced by different manufacturers, was determined by measuring the performance of the materials in SMDC end boosters.

The test method and equipment selected for this task was the McDonnell Douglas Corporation Energy Sensor,[5] shown in Figure 21, which utilizes precalibrated aluminum honeycomb as a crushable element whose crush strength is defined in inch-pounds. The SMDC tip is detonated with a resulting output of hot gases and steel fragments which crushes the aluminum honeycomb by pushing a piston in the energy sensor. The measurement of energy output is determined from the length of honeycomb crushed in the energy sensor. Each honeycomb element is precalibrated to determine the crush force. This force multiplied by the distance (length of honeycomb crushed) yields the effective energy of the explosion used to do work. This test was used during development qualification and is still used for the acceptance testing of F-111 aircraft SMDC hardware. As a result of many thousands of test firings that have been made, the average energy output, and variation of output is well established.

TABLE 6. SUMMARY OF FRAGMENT SENSITIVITY, CHEMICAL ASSAY, AND SURFACE AREA ANALYSIS FOR HNS

NSWC ID #	HNS TYPE	APPROX. 50%-FIRE ACCEPTOR CLOSURE THICKNESS	% HNS	% HNBiB	% TNB	SURFACE AREA ANALYSIS* cm^2/cm^3
2232	I	0.020	98.0	1.7	0.3	52,165
2247	I	0.020	99.5	0.5	None	128,336
2297	I	0.020	94.5	4.6	0.1	47,929
2087	I	0.017	99.2	0.6	Trace	26,818
2130/2134	I	0.020	99.0	0.7	None	67,297
1479	II	0.010	99.5	0.2	None	8,996
2299	II	0.010	99.6	None	None	8,996
2323	II	0.010	98.7	None	None	7,612

*Surface area measurements consisted of an average value determined from two test runs on a Micrometrics High-Speed Surface Analyzer Model 2205. Accuracy is within 3 percent.

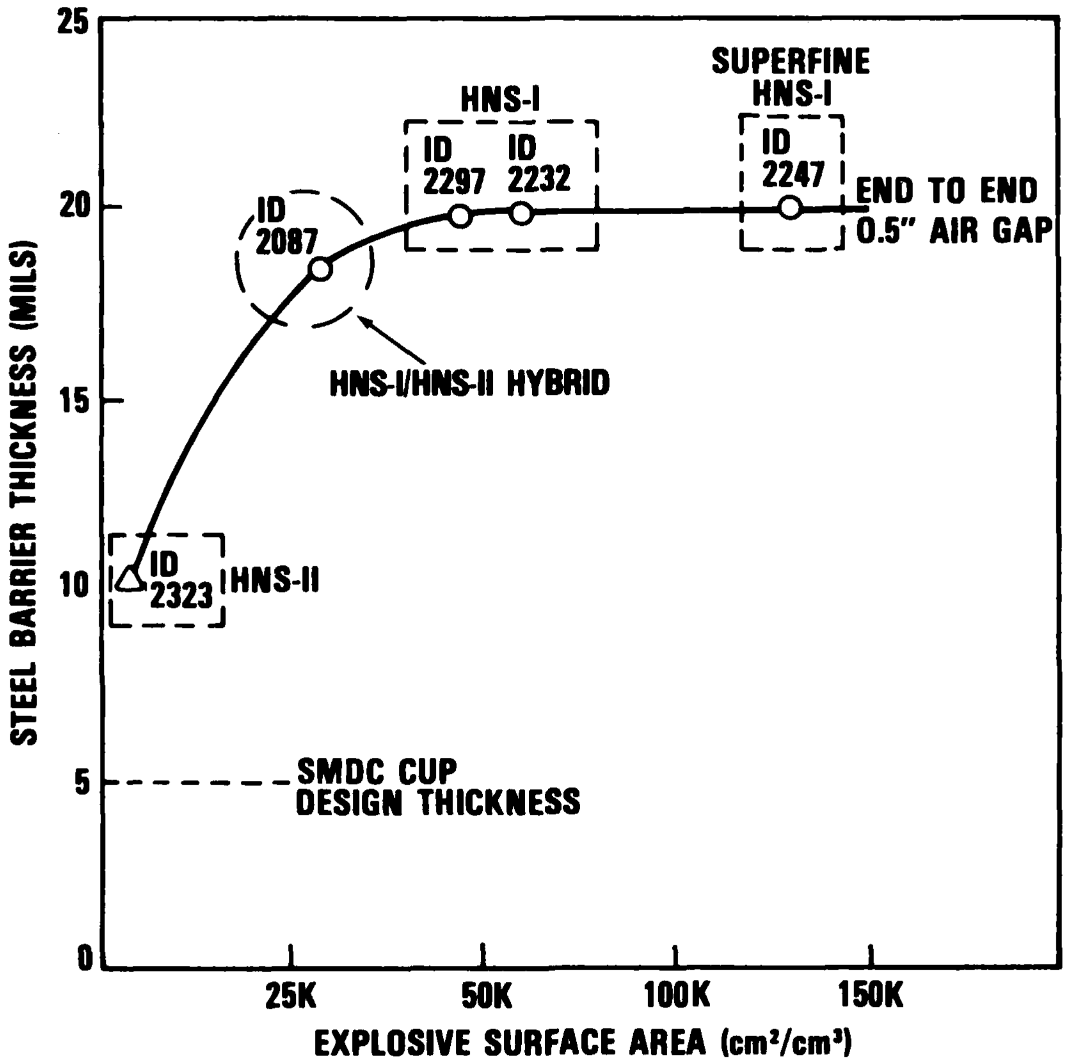


FIGURE 19. HEXANITROSTILBENE–FRAGMENT INITIATION SENSITIVITY AT A 50% FIRE RESPONSE WITH STEEL BARRIER THICKNESS VERSUS EXPLOSIVE SURFACE AREA AT THE 0". 500 AIR GAP (END-TO-END CONFIGURATION)

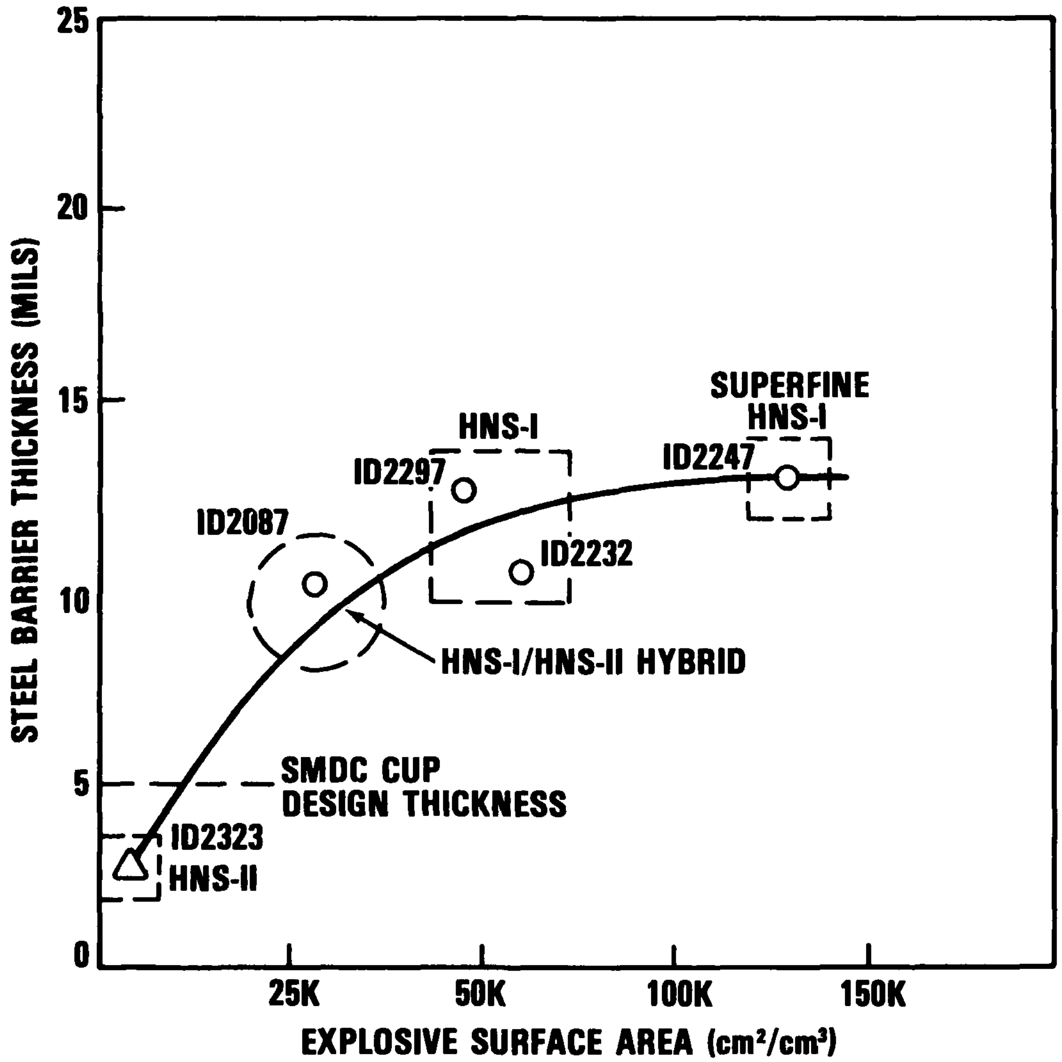


FIGURE 20. HEXANITROSTILBENE–FRAGMENT INITIATION SENSITIVITY AT A 50% FIRE RESPONSE WITH STEEL BARRIER THICKNESS VERSUS EXPLOSIVE SURFACE AREA AT THE 0". 100 AIR GAP (SIDE-TO-END CONFIGURATION)

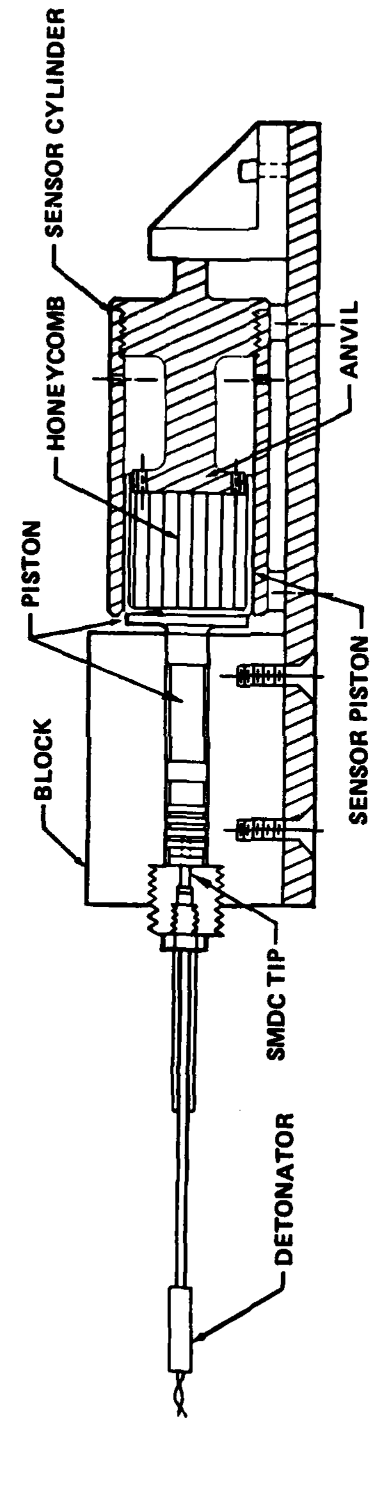


FIGURE 21. SMDC OUTPUT TEST FIXTURE (MCDONNELL DOUGLAS CORP.)

The explosives tested were selected from representative production lots of HNS-I produced by several vendors. All of these vendors were the primary producers of HNS-I in the United States except for one vendor in England. The object of the selection was to determine if HNS-I, as a production explosive, would show any variable output when used in the SMDC vehicle. The Naval Surface Weapons Center (NSWC) identification and vendor lot identification are shown in Table 7. The energy sensor is identified as a MCAIR P/N 12K016-07 Initiator Output Test Fixture. The standard for the tests was F-111 SMDC end tips furnished by MCAIR. SMDC lines were loaded with explosive from the various vendors and fabricated by Explosives Technology.

A total of 84 SMDC-end tip energy output tests were conducted at ambient temperature. In addition to the 70 tests with the NSWC-supplied end tips, 14 tests were performed with the F-111 end tips for control data. Initially, six F-111 end tips were fired to verify proper functioning of the energy sensor; then eight more F-111 end tip firings were interspersed throughout the tests of the NSWC-supplied end tips.

The test pattern used for the remaining NSWC-supplied end tips is as follows: of the first 35 NSWC-supplied end tips tested, 5 end tips from one of the seven lots were fired before proceeding to five from the next lot, etc. With the last 35 NSWC-supplied end tips tested, one end tip from the first lot was fired followed by one from the second lot, etc., rotating through the seven lots sequentially five times.

The results obtained from the F-111 end tip control firings are compared to NSWC supplied tips in Table 8. The results obtained from all the NSWC-supplied end tip test firings are tabulated in Tables 8 and 9.

CONCLUSIONS AND RECOMMENDATIONS

1. The unexpected result in the detonation transfer failure of one British lot of HNS (PERME B343) is probably caused by the high acid content and not by the percentage of other impurities in the sample. The other lots of HNS from various vendors did transfer detonation after exposure to elevated temperature of 260°C (500°F) with the high HNBiB impurity.

2. The performance of HNS-I in the end tips is satisfactory after aging at 218°C (425°F) over a period of 24 hours.

3. The performance of HNS-I in the end tips is satisfactory after aging at 260°C (500°F) for 2 hours except for the British material which showed the high acid assay and failed.

4. The performance of HNS-I in the end tips is <u>not satisfactory</u> after exposure at 280°C (540°F). The tips deflagrated during a 1-1/2 hour exposure at this temperature. Not only the HNS-I in the end tips, but also the HNS-II in the detonating cords started to decompose, causing swelling of the sheath and an extrusion of the explosive column from the ends of the cord.

TABLE 7. EXPLOSIVES/VENDOR IDENTIFICATION

NSWC INDENTIFICATION	VENDOR IDENTIFICATION
2297	UTC Lot #3
2232	British PERME 343
2282	Chemtronics 114-11
2407	Pantex 7157-07C-001
2132	Tel/McC/Selph 1014
2413	UTC Lot #8
2417	British B553

TABLE 8. MEASURED ENERGY OUTPUT OF NSWC-SUPPLIED TIPS AND F-111 CONTROL TIPS

	PANTEX LOT 7157-07C-0001 NO. 2407 ENERGY (IN-LB)	UTC LOT 8 NO. 2413 ENERGY (IN-LB)	BRIT. PERME 553 NO. 2417 ENERGY (IN-LB)	EXPL. TECH./McDONNELL DOUGLAS F-111 CONTROL TIPS (IN-LB)	
	414	440	331	405	461
	572	420	402	347	417
	412	393	402	353	578
	406	459	386	362	405
	443	378	418	398	
	246*	322	336	342	
	467	384	467	340	
	216*	480	462	346	
	436	346	376	444	
	437	184*	354	481	
Total:	3587	3622	3934	5679	
Average:	448	402	393	406	

*Denotes: inaccurate (low) value not included in column total and average. These flagged values occurred during tests in which explosive-generated gas leaked past or expelled the reused aluminum nut holding the SMDC-tip in the test-fixture adapter.

TABLE 9. MEASURED ENERGY OUTPUT OF NSWC-SUPPLIED TIPS

	T/M/C LOT 1014 NSWC ID NO. 2132 ENERGY (IN-LB)	BRIT. PERME 343 NO. 2232 ENERGY (IN-LB)	CHEM. LOT 114-11 NO. 2282 ENERGY (IN-LB)	UTC LOT 3 NO. 2297 ENERGY (IN-LB)
	341	242	297	222*
	319	230*	294	313
	316	305	302	322
	329	378	443	286
	281	445	338	316
	443	428	431	396
	395	314	266	311
	477	439	420	409
	433	444	355	469
	346	331	389	373
Total:	3680	3326	3535	3195
Average:	368	370	354	355

*Denotes: inaccurate (low) value not included in column total and average. These flagged values occurred during tests in which explosive-generated gas leaked past or expelled the reused aluminum nut holding the SMDC-tip in the test-fixture adapter.

5. The testing of HNS-I and HNS-II by the McDonnell "QUEST METHOD" resulted in distinguishing between the two materials on the basis of output energy. It is not sensitive enough to show differences between lots of HNS-I.

6. All materials tested from vendors in the United States and England are acceptable for use in SMDC hardware except for use at elevated temperatures (see 3. above, where high acid assay material decomposition is discussed).

7. Comparison of explosive particle surface area analyses and sensitivity to fragment initiation reveals that the HNS-I minimum surface area should be greater than 27,000 cm^2/cm^3 (approximately 1.55 m^2/g).

8. HNS-II is not recommended for use in SMDC end booster design (this remark does not apply to the detonating cord). Marginal performance is expected since test results indicate 3 mils of steel barrier will yield a 50 percent fire response to other SMDC tips in a side-to-end configuration.

9. Within the limitations of the energy sensor capability (QUEST), there is no significant energy output difference among the seven HNS lots tested, since each lot produced an average energy value within the 400 $\pm$ 50 in-lb range. Also, none of the test lots shows much statistical difference from the results obtained with the F-111 end tips, which averaged 406 in-lb. Finally, all of the data obtained during this test program is comparable to that obtained over the past years from acceptance tests with new F-111 and F-15 SMDC-end tips.

10. It appears that HNS-I manufactured throughout the United States and England will perform in the SMDC vehicle.

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